CHAPTER 2 | KINEMATICS IN ONE DIMENSION

CONCEPTUAL QUESTIONS

13. REASONING AND SOLUTION  Two objects are thrown vertically upward, first one, and then, a bit later, the other. The time required for either ball to reach its maximum height can be found from Equation 2.4: \( v = v_0 + at \). At the maximum height, \( v = 0 \); solving for \( t \) yields, \( t = -v_0 / a \) where \( a \) is the acceleration due to gravity. Clearly, the time required to reach the maximum height depends on the initial speed with which the object was thrown. Since the second object is launched later, its initial speed must be less than the initial speed of the first object in order that both objects reach their maximum heights at the same instant. The maximum height that each object attains can be found from Equation 2.9: \( v^2 = v_0^2 + 2ay \). At the maximum height, \( v = 0 \); solving for \( y \) gives, \( y = v_0^2 / 2a \) where \( a \) is the acceleration due to gravity. Since the second object has a smaller initial speed \( v_0 \), it will also attain a smaller maximum height. Thus, it is not possible for both objects to reach the same maximum height at the same instant.

PROBLEMS

38. REASONING AND SOLUTION
   a. Once the pebble has left the slingshot, it is subject only to the acceleration due to gravity. Since the downward direction is negative, the acceleration of the pebble is \(-9.8 \text{ m/s}^2\).

   b. The displacement \( y \) traveled by the pebble as a function of the time \( t \) can be found from Equation 2.8. Using Equation 2.8, we have

   \[
   y = v_0 t + \frac{1}{2} a t^2 = (-9.0 \text{ m/s})(0.50 \text{ s}) + \frac{1}{2} \left[(-9.80 \text{ m/s}^2)(0.50 \text{ s})^2\right] = -5.7 \text{ m}
   \]

   Thus, after 0.50 s, the pebble is \( 5.7 \text{ m} \) beneath the cliff-top.

47. REASONING  The initial speed of the ball can be determined from Equation 2.9 \( (v^2 = v_0^2 + 2ay) \).
   Once the initial speed of the ball is known, Equation 2.9 can be used a second time to determine the height above the launch point when the speed of the ball has decreased to one half of its initial value.

   SOLUTION  When the ball has reached its maximum height, its velocity is zero. If we take upward as the positive direction, we have from Equation 2.9

   \[
   v_0 = \sqrt{v^2 - 2ay} = \sqrt{0^2 - 2(-9.80 \text{ m/s}^2)(16 \text{ m})} = 18 \text{ m/s}
   \]

   When the speed of the ball has decreased to one half of its initial value,
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and Equation 2.9 gives

\[
v = \frac{v_0}{2}
\]

\[
y = \frac{v^2 - v_0^2}{2a} = \frac{(v_0 / 2)^2 - v_0^2}{2a} = \frac{v_0^2}{2a} \left( \frac{1}{4} - 1 \right) = \frac{(18 \text{ m/s})^2}{2(-9.80 \text{ m/s}^2)} \left( \frac{1}{4} - 1 \right) = 12 \text{ m}
\]

59. **REASONING**  The average velocity for each segment is the slope of the line for that segment.

**SOLUTION**  Taking the direction of motion as positive, we have from the graph for segments A, B, and C,

\[
v_A = \frac{10.0 \text{ km} - 40.0 \text{ km}}{1.5 \text{ h} - 0.0 \text{ h}} = -2.0 \times 10^1 \text{ km/h}
\]

\[
v_B = \frac{20.0 \text{ km} - 10.0 \text{ km}}{2.5 \text{ h} - 1.5 \text{ h}} = 1.0 \times 10^1 \text{ km/h}
\]

\[
v_C = \frac{40.0 \text{ km} - 20.0 \text{ km}}{3.0 \text{ h} - 2.5 \text{ h}} = 40 \text{ km/h}
\]

60. **REASONING AND SOLUTION**

a. The sign of the average velocity during a segment corresponds to the sign of the *slope* of the segment. The slope, and hence the average velocity, is *positive* for segments A and D, *negative* for segment C, and ZERO for segment B.

b.

\[
v_A = \frac{1.00 \text{ km} - 0 \text{ km}}{0.20 \text{ s} - 0 \text{ s}} = 5.0 \text{ km/h}
\]

\[
v_B = \frac{1.00 \text{ km} - 1.00 \text{ km}}{0.40 \text{ s} - 0.20 \text{ s}} = 0.0 \text{ km/h}
\]

\[
v_C = \frac{0.25 \text{ km} - 1.00 \text{ km}}{0.60 \text{ s} - 0.40 \text{ s}} = -3.8 \text{ km/h}
\]

\[
v_D = \frac{1.25 \text{ km} - 0.25 \text{ km}}{1.00 \text{ s} - 0.60 \text{ s}} = 2.5 \text{ km/h}
\]

65. **SSM REASONING AND SOLUTION**  The speed of the penny as it hits the ground can be determined from Equation 2.9: \( v^2 = v_0^2 + 2ay \). Since the penny is dropped from rest, \( v_0 = 0 \). Solving for \( v \), with downward taken as the positive direction, we have

\[
v = \sqrt{2(9.80 \text{ m/s}^2)(427 \text{ m})} = 91.5 \text{ m/s}
\]